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(54) Title: ELECTRICAL CONNECTOR FOR THERAPEUTIC DEVICES

(57) Abstract

A connector (16) for a therapeutic device such as a cochlear implant system, having an implanted component (14) and an external component (10) has an implant connector portion (21) and an external connector portion (36). Implant connector portion (21) has contact areas (32 and 34) and external contact portion (36) has contact areas (54). A magnet (30) biases the contact areas (32, 34 and 54) toward each other.

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ELECTRICAL CONNECTOR FOR THERAPEUTIC DEVICES

TECHNICAL FIELD

This invention pertains to an electrical connector for therapeutic devices, and more particularly to a multiple contact connector having magnetic biasing.

BACKGROUND ART

Many therapeutic devices used today are complex electronic devices making use of sophisticated circuitry. Some of these devices, such as cochlear implants used to aid patients suffering from acute hearing loss, consist of two components, namely an implanted portion, and an external portion. These two portions must communicate with each other for proper operation. Several schemes are known for providing a communication channel between an implanted and an external component.

One such device consists of a jack-and-plug type connector with the plug being connected to the external component, and the jack being incorporated into the implanted device. This device provides a solid, hard-wired connection between two components. However it is undesirable because the jack could be dislocated during disconnection and therefore provide a source of infection. In addition, the connection may be difficult to use, especially by elder persons, it is not water proof and may be aesthetically objectionable.

Another type of communication channel is provided by using an inductive coupling. This scheme uses an inductive coil in each component. When the coils are positioned adjacent to each other, they are inductively coupled and can be used to transmit electromagnetic signals through the skin of the patient in either direction. However, both lateral positioning and the axial spacing between the coils are crucial for effective communication. If the coils are not positioned correctly, the amplitude and energy level of the transmitted signals are severely attenuated.

This problem is especially acute for certain types of cochlear implants which rely on these signals not only for their information content but also for the application of power to the implanted component. Naturally, if the signals are attenuated, their energy level and hence power applied to the implanted component is also diminished. Additionally, this type of connection scheme may provide electromagnetic signals which may interfere with the operation of the external component.

U.S. Patent No. 4,736,747 discloses a transcutaneous coupling apparatus using inductive coupling as the communication channel in which a magnet is used to position the coils. However, this arrangement requires many components and is expensive to manufacture. Moreover, all systems making use of inductive coupling need transmitting and receiving subsystems in both the external and the implanted components, thus increasing the complexity of the system and its power requirements.

DISCLOSURE OF THE INVENTION

According to one aspect of the invention there is provided a connector for a therapeutic device having an implanted portion and an external portion, said connector comprising:

an implant connector portion constructed and arranged for subcutaneous insertion, said implant connector portion having connection means defining an implant connection contact area positioned in a planar relationship with the patient's skin;

an external connector portion for mounting on the external portion, said external connector portion having an external contact area; and

means for biasing one of said external and implant contact areas against the other contact area to define an electrical path therebetween.

According to another aspect of the invention there is provided a therapeutic system comprising:

an implant portion arranged and constructed for implantation into a patient, said implant portion including an internal connector having a plurality of contacts, each contact having a contact area disposed in a coplanar position with respect to the patient skin in an opening thereof;

an external portion to be worn by the patient, said external portion including an external connector portion having an equal plurality of external contacts, each external contact having an external contact area; and

biasing means for biasing each contact area of one

portion against a corresponding contact area of the other portion to establish an electrical path therebetween.

According to still another aspect of the invention there is provided a cochlear implant system comprising:

an external component for receiving ambient sounds and generating corresponding electrical signals and having an external housing;

an implantable component for receiving said electrical signals and generating corresponding stimulation signals and having an implantable housing; and

connecting means for connecting said components, said connecting means including a first contact area disposed on said external component, a second contact area arranged and constructed for subcutaneous implantation, means coupling said second area to said internal component, and biasing means or biasing said contact areas toward each other.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic representation of a cochlear implant system with a connector constructed in accordance with an embodiment of this invention;

Fig. 1A shows a variation on the embodiment of Fig. 1;

Fig. 2 is a cross-sectional view of the implanted portion of the connector of Fog. 1;

Fig. 3 is a front view of the connector portion of Fig. 2;

Fig. 4 is an enlarged side sectional view of the connect r porti n of Figs. 2 and 3;

Fig. 5 is a side view of the external portion of the connector if Fig. 1;

Fig. 6 is a top view of external connector portion of Fig. 5;

Fig. 7 is a side sectional view of the implanted connector portion of a second embodiment of the invention;

Fig. 8 is a front view of the implanted portion of Fig. 7;

Fig. 9 is a front view of the implant connector portion of a third embodiment of the invention;

Fig. 10 is a somewhat diagrammatic front view of a fourth embodiment of the invention;

Fig. 11 is a side sectional view of the implant portion of the connector of Fig. 9;

Fig. 12 is a front view of the external portion of the connector of Fig. 9;

Fig. 13 is an enlarged top view of the external portion of Fig. 12;

Fig. 14 is a top view of the external portion of Fig. 12;

Fig. 15 is a front view of a fifth embodiment of the invention;

Fig. 16 is a view of the embodiment of Fig. 14 from the inside showing the contact plates;

Fig. 17 is a top view of the complete assembly of Fig. 14;

Fig. 18 is an enlarged cross-section of the contact plate and magnet of the embodiment of Fig. 14; and

Fig. 19 is a cross-section of the contacts, the magnet and the connection to a possible location of the implant circuit;

MODES FOR CARRYING OUT THE INVENTION

The cochlear implant system shown in Fig. 1 includes a behind-the-ear external or processor component 10 resting on the ear 12 of a patient. The cochlear system further includes an implanted component 14, a connector 16 and a pair of wires 18 extending subcutaneously from the implant 14 to the connector 16. As shall be described in more detail below, the external component 10 is directly coupled to the connector 16 so that no external wiring is necessary. Alternatively, the connector 16 can be an integral part of the implant as shown in Fig. 1A, eliminating the connecting wires.

Briefly, the external component 10 includes a microphone 20 for picking up ambient sounds. These sounds are converted and processed by the external component 10 and converted into processed signals. These processed signals are sent through connector 16 via wires 18 to the implanted component 14 or directly if the contacts and the implant are integrated. The implanted component 14 converts the data into analog electrical signals and applies stimulus to the aural nerve of the patient by an electrode array 11 in a mann r well known in the art.

Referring to Figs. 2-4, the connector 16 includes an implant portion 21 which is surgically inserted and secured under the skin surface 22. The component 21 includes a molded housing 24 holding two semi-cylindrical members 26, 28, separated by a permanent magnet 30. The magnet 30 is disposed at right angles to the skin surface 22. The members 26, 28 may also be made of a magnetically permeable material such as a conductive ferromagnetic alloy. An end of each wire 18 is welded to one of the members 26, 28 respectively, as seen at W in Fig. 4. The outer surfaces 32, 34 of members 26, 28 are positioned and arranged just below or approximately even with the skin surface 22 and are generally semi-circular, as seen in Fig. 3 to provide two contact areas.

Details of the external portion 36 of the connector 16 are shown in Figs. 5 and 6. The external portion 36, which is disposed in a depression 37, includes an elongated sheet 38 made of a non-conductive material such as MYLAR which has near one end an elongated or oval slot 40. The external portion 36 further includes a clamping plate 42 disposed at one end of the sheet 38 as shown in Fig. 6. Preferably, plate 42 is made of a non-conductive material. A screw 44 which passes through the plate 42, and slot 40 is used to secure the plate 42 and the sheet 38 to the housing 46 of external component 10. The position of the sheet 38 may be adjusted as desired with respect to the housing 46 because of the oval slot 40.

Sheet 38 is formed with two elongated elements 48 and 50. These elements 48, 50 may be formed on the sheet 38, for example, by electroplating. Each element 48, 50 is terminated with a respective contact area 54, made of permanent magnetic material and plated with a conductive metal such as gold. The sheet 38 is relatively thin and flexible to permit the end disposed away from the body 46 to flex.

Under the plate 42, the housing 46 is formed with two plated parallel tracks, one track 52 being shown in Fig. 6. These tracks are connected by means not shown with the internal circuitry of component 46. When the plate 42 clamps the sheet 36 to housing 46, each of the contacts 54 connected to elements 48, 50 are pressed against, and make electrical contact with each of the tracks 42 and 52.

When the external component 10 is positioned on the ear 12 by the patient, in the position shown in Fig. 1, the force from magnet 30 attracts the elements 54 of the external connector portion 36 towards the elements 26, 28 of the implant portion 21 to bias the two connector portions toward each other with the sheet 38 flexing inwardly toward the skin surface 22 until the contact areas 54 touch respective contact areas 32, 34. In this manner, the connector 16 provides effective hard-wired contact between the external component 10 and implant 14. Moreover, the magnetic force between the connector portions provides support for the

external component 10. Thus, connection between the components of the cochlear implant takes place automatically without any tedious steps on the part of the patient. Moreover, it should be appreciated that the contact areas are self aligning and biasing to insure proper contact through the respective contact areas.

The external component can be easily tailored to the physical dimensions and characteristics of the patient by shifting the sheet 38 as described above.

Another embodiment of the implant portion is shown in Figs. 7 and 8. In this embodiment, the implant portion has a housing 20A containing two cylindrical members 26A, 28A, and permanent magnet 30B is U-shaped with legs extending adjacent to contact areas 32A, 34A as shown if Fig. 8. The external component can be as shown in Figs. 5 and 6.

Another embodiment of the implant portion is shown in Fig. 9, which is similar to the one in Figs. 2 to 4 except that instead of two members, three members are used, each having an accurate contact area 26B, 28B, 29B disposed about magnet 30B. For this embodiment, the external portion must be modified slightly by adding another strip on sheet 38 to make contact with contact area 29B.

The contact arrangement of Figs. 8 and 9 can be incorporated into the implant to eliminate the connecting wires as described previously in reference to Fig. 1A.

Figs. 10-14 show yet another embodiment of the invention. In this embodiment, the implant connector porti n

120 consists a housing with a molding or potting material 121. A pair of contacts 126, 128 are embedded in the material 121 and are made of magnetic material such as nickel and coated with an electrically conducting film made for example, of gold or similar low resistance material. Each contact is welded to a corresponding wire 118.

The contact arrangement of Fig. 11 can be incorporated in the implant 14 to eliminate the connecting wires as described previously in reference to Fig. 1A.

The behind-the-ear processing unit 110 includes a microphone 120 disposed on a housing 146. This housing 146 is formed with an indentation 147 for holding a pair of c-shaped springs 148, 150. Spring 150 is made of a relatively light material, such as mylar, and has two opposing ends 145, 149. End 145 is secured to housing 146 by some means such as a rivet 151. Rivet 151 is made of an electrically conductive material such as gold, or copper and in addition to mounting spring 150, it also provides connection to the internal wiring (not shown) of processor 110. Attached to the back surface of the mid-section of spring 150 there is a permanent magnet 153. Opposite this magnet 153, the spring is provided with a relatively flat plate 155 made of a material such as nickel. Spring 148 has the same construction as spring 150.

When the external or processor unit 110 is installed by the patient in the position shown in Fig. 10, the spring 150 is disposed so that its plate 155 is aligned with the contact

area 132 of contact 126. The magnet 153 magnetizes both plate 155 and contact 126 and biases the same toward each other whereby the plate 155 comes into physical contact with the contact area 132. In this manner an electrical contact is established between an internal conductor or processor 110 (not shown) and wire 118 through the spring 150, plate 155, and contact 126. A similar electrical path is established between another internal conductor of processor 10 (not shown), spring 148, contact 128 and wire 118. Moreover, the magnetic biasing between the connector portion insures the connector portions remain connected until the patient removes the external portion 120. The flexible shape of springs 148, 150 and their floating ends, such as end 149, compensate automatically for the shape of the patient's head, as can be seen in Fig. 14.

The contact arrangement of Fig. 10 can be incorporated in the implant 114 to eliminate the connecting wires as described previously on reference to Fig. 1A.

A further embodiment of the invention is shown in Fig. 15. In this version, two fixed conducting plates 60 and 62 are attached to the processor 10. These contain magnets 70 on the inside faces (see Fig. 18). The plates 60 and 62 are connected to the circuitry of 10 by means not shown. An implant housing 66 is provided with the contacts 64 molded as an integral assembly. The housing could also include the data processing electronics or alternatively, the electronics could be disposed in a separate housing as in Fig. 1 and connected by wires in a manner similar to Fig. 11.

The contacts 64 are preferably magnets of opposite polarity to the magnets 70 or they may be made of magnetic material such as nickel. Alternatively a magnet or magnetic material may be incorporated in the implant 72. The contacts 64 would be plated or coasted in a material such as platinum to make them compatible to body fluids in a subcutaneously implant.

To minimize movement of the processor 10 with respect to the contacts, one or both plates 60, 62 may be lightly etched or cross-hatched so that one or both the contacts 64 engage with the surface to prevent movement.

Fig. 19 is a cross-section through the contacts 64 showing their relation to the skin 68. Magnetic material 72 is shown located between the contacts and electronic circuit 74.

Obviously, numerous modifications may be made to this invention, without departing from its scope as defined in the appended claims.

INDUSTRIAL APPLICABILITY

The connector of the invention may be used to connect the internal and external components of therapeutic devices.

CLAIMS:

1. A connector for a therapeutic device having an implanted portion and an external portion, said connector comprising:

an implant connector portion constructed and arranged for subcutaneous insertion, said implant connector portion having connection means defining an implant connection contact area positioned in a planar relationship with the patient's skin;

an external connector portion for mounting on the external portion, said external connector portion having an external contact area; and

means for biasing one of said external and implant contact areas against the other contact area to define an electrical path therebetween.

2. The connector of claim 1 further comprising adjustment means for adjusting a position of one of said contact areas.

3. The connector of claim 1 wherein said biasing means includes a permanent magnet for generating a magnetic biasing force between said connector portions.

4. The connector of claim 1 wherein said implant portion is disposed under said skin and wherein said contact areas are biased against each other through an opening through said skin.

5. A therapeutic system comprising:

an implant portion arranged and constructed for implantation into a patient, said implant portion including an internal connector having a plurality of contacts, each contact having a contact area disposed in a coplanar position with respect to the patient's skin in an opening thereof;

an external portion to be worn by the patient, said external portion including an external connector portion having an equal plurality of external contacts, each external contact having an external contact area; and

biasing means for biasing each contact area of one portion against a corresponding contact area of the other portion to establish an electrical path therebetween.

6. The system of claim 5 wherein said biasing means includes a magnet for generating a biasing magnetic field.

7. The system of claim 6 wherein said magnet is disposed in said implant portion.

8. The system of claim 6 wherein said magnet is disposed in said external portion.

9. The system of claim 5 further comprising adjusting

means for adjusting the position of the external contact areas.

10. A cochlear implant system comprising:

an external component for receiving ambient sounds and generating corresponding electrical signals and having an external housing;

an implantable component for receiving said electrical signals and generating corresponding stimulation signals and having an implantable housing; and

connecting means for connecting said components, said connecting means including a first contact area disposed on said external component, a second contact area arranged and constructed for subcutaneous implantation, means coupling said second area to said internal component, and biasing means for biasing said contact areas toward each other.

11. The system of claim 10 wherein said contact areas are each fixed to one of said housings.

12. The system of claim 10 wherein connecting means includes a flexible member having one end attached to one of said housings, one of said contact areas being mounted on said flexible members.

13. The system of claim 12 wherein said flexible member is attached to said external housing.

14. The system of claim 12 wherein said flexible member has a central portion and a second end, said one contact area being mounted on said central portion.

15. The system of claim 14 wherein said second end is floating.

16. The system of claim 14 wherein said second end is fixed to the corresponding housing.

17. The system of claim 10 wherein said biasing means includes a permanent magnet.

18. The system of claim 17 wherein each area includes a first and a second contact point.

19. The system of claim 18 wherein said permanent magnet is disposed between said points.

20. The system of claim 18 wherein said points are magnetic.

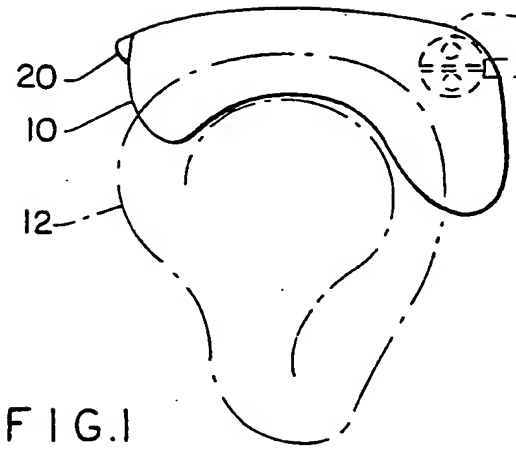


FIG.1

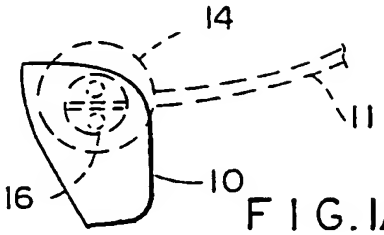


FIG.1A

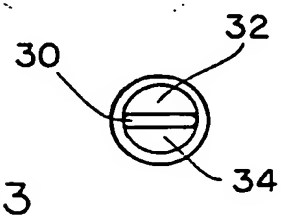


FIG.3

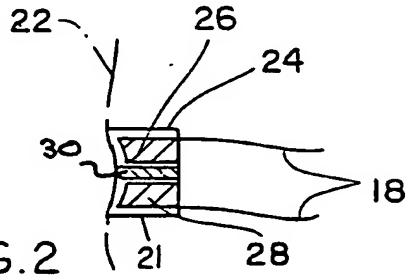


FIG.2

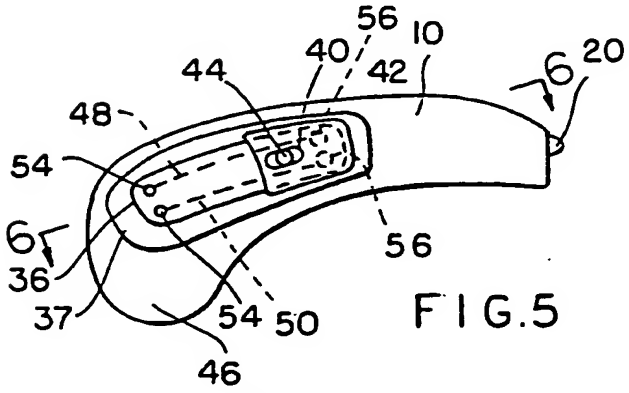


FIG.5

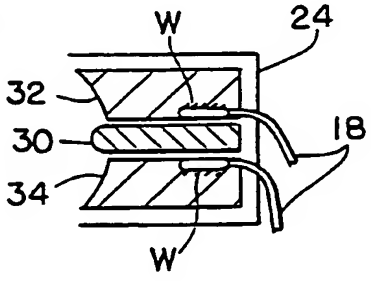


FIG.4

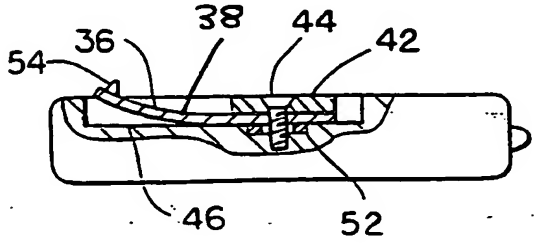


FIG.6

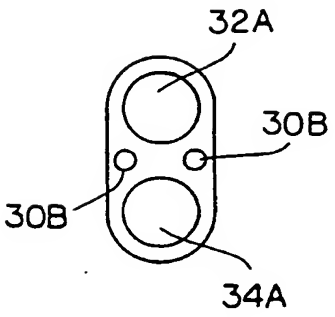


FIG.8

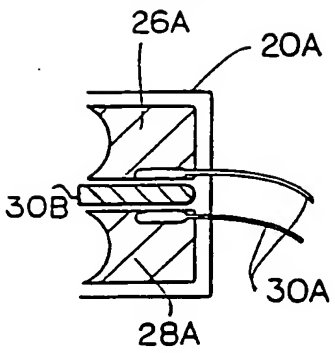


FIG.7

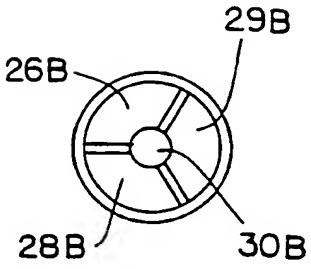


FIG.9

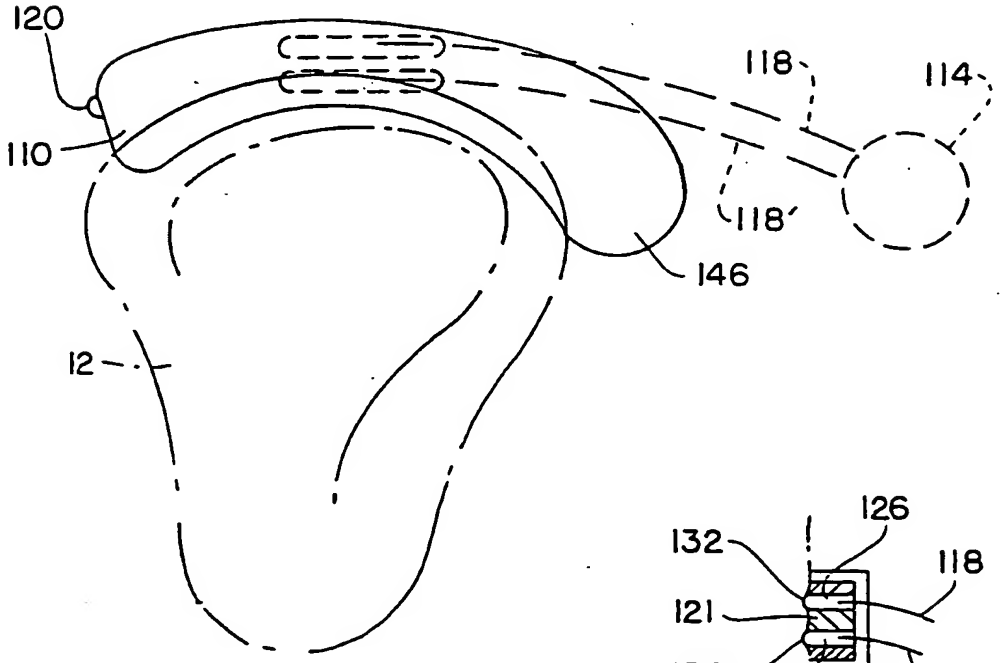


FIG.10

FIG.11

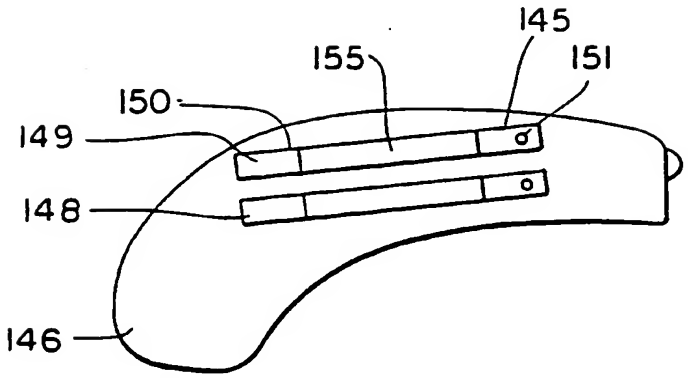


FIG.12

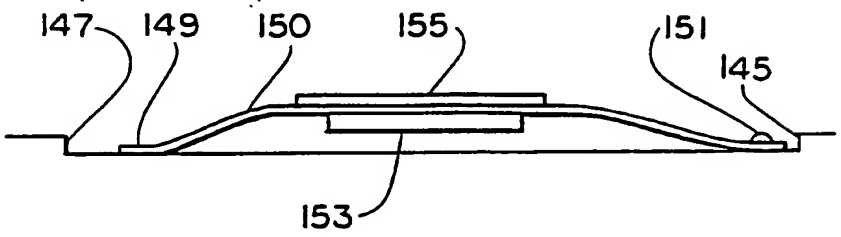


FIG.13

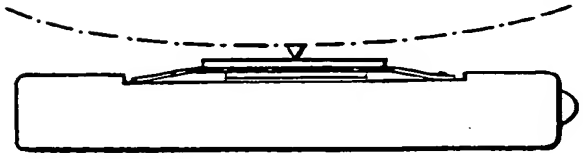
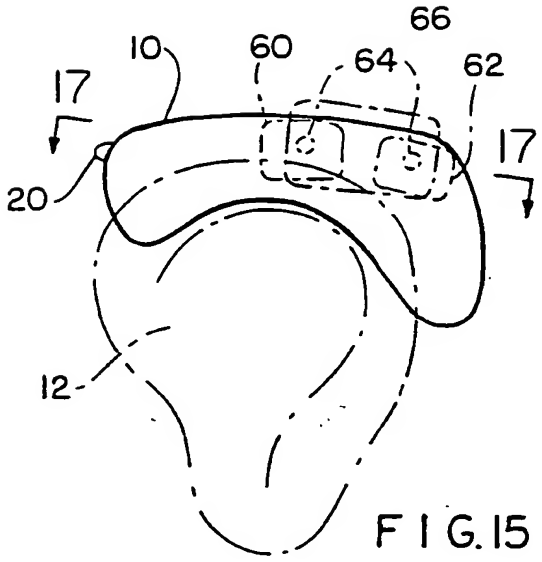
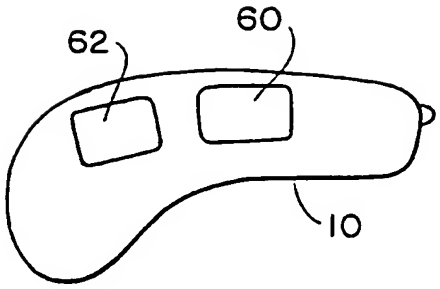


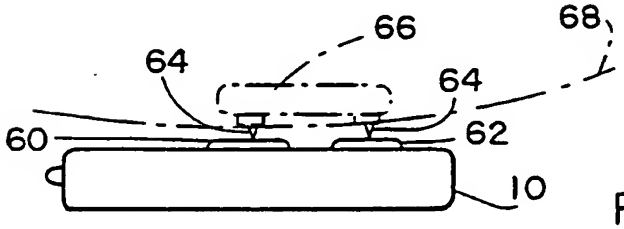
FIG.14



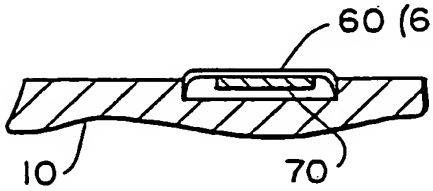
F I G. 15



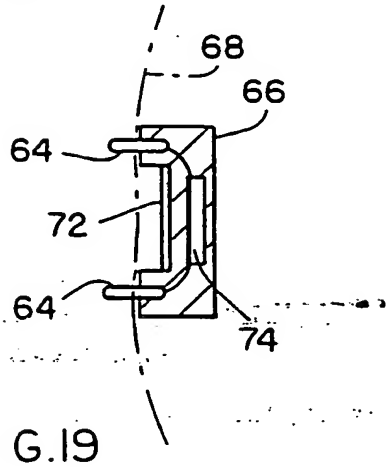
F I G. 16



F I G. 17



F I G. 18



F I G. 19

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 95/00469

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: H01R 13/639, A61F 11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: H01R 13/62, 13/629, 13/631, 13/639, A61F 11/04, A61N 1/02, 1/36, 1/37, 1/372, 1/378

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT, IPC as above for H01R with KEYWORD: MAGNET:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 18941/92 A1(COCHLEAR PTY LTD) 10 December 1992 Fig 1-3, Pages 2-4	1, 3-8,10,11,17,18
X	US 4025964 A (OWENS) 31 May 1997 Fig 1, Columns 2-4	1, 3, 4, 10, 11, 17,18
A	US 4352960 A (DORMER) 5 October 1982	

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

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Date of the actual completion of the international search	Date of mailing of the international search report
6 OCTOBER 1995	26 OCTOBER 1995

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 95/00469

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4736 747 A (DRAKE) 12 April 1988	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 95/00469

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU.	18941/92	EP	587649	WO	9222107		
US	4736747	AU	70147/87	CA	1301254	EP	241307
							END OF ANNEX